



Technical Issues Update: U.L. Certifications and Fuel Testing

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Energy Laboratory**

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Alternative sources and alternative fuels...

DOE addressing issues in both fields

Alternative sources of Traditional fuels



Alternative fuels



US Department of Energy's role

- Overarching: Displacement of oil imports, lessening our nation's dependence on foreign oil
- Long-standing interest in alternative fuels
 - E85, CNG, LPG
- Many programs developed to assist in the deployment, such as Clean Cities
- Many programs developed to assist in developing a market for alternative fuels (where it makes sense), and respond to legislation, such as EPA Act
- Provide funding for national labs conduct R&D to determine feasibility, identify market barriers

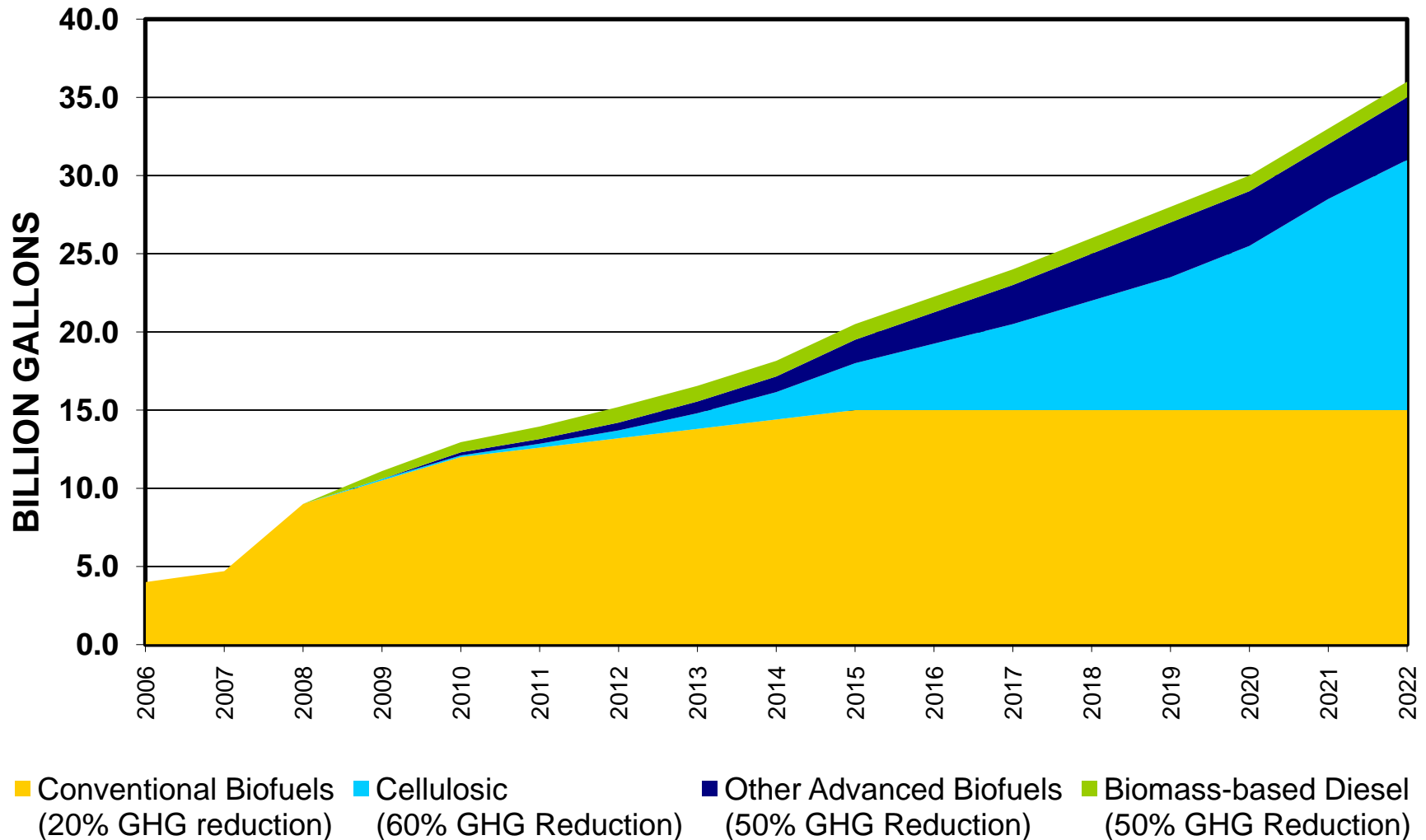


U.S. DOE Activities in Biofuels

- Support R&D in many types and uses of biofuels, often with industry partners
- Call for reducing costs of most efficient and promising options
- Analyze type and quantity of air emissions and seek most environmentally benign choices
- Analyze infrastructure opportunities, options, and issues
- Working with others on standards for uniform product quality



Renewable Fuels Standard (RFS)



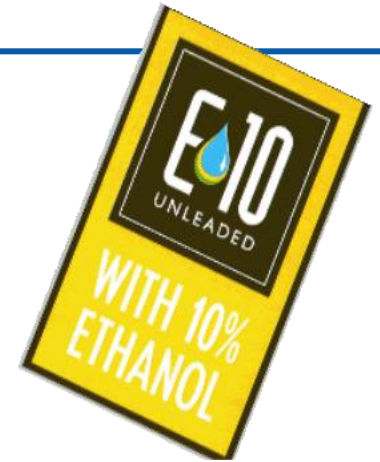
Developing A Ready End-Use Market for Ethanol

- 9.64 billion gallons of ethanol was used in the U.S. in 2008
 - More than 99% is used in the form of E10
 - E10 market will be saturated at about 14 billion gallons = The Blend Wall
- DOE strategy for expanding ethanol use
 - Greatly expand E85 use
 - Determine feasibility of using intermediate ethanol blends (e.g., E15, E20) in conventional vehicles (non-flex fuel vehicles)
- EPA has authority to issue a “substantially similar” waiver to allow alternative fuels to be used in place of gasoline
 - Evaluated in terms of effects on durability, driveability, materials, and emissions
 - DOE labs working to provide data
 - Waiver request 3/09; decision due 12/09



Ethanol as a Fuel & Fuel Additive

- E10 (10% ethanol by volume)
 - Approved for use in all vehicles and engines
 - ~98% of ethanol consumed as E10
 - 80% of U.S. gasoline blended with ethanol
- E10+ blend
 - E10+ is gasoline containing ethanol at greater than 10% volume for use in conventional (non-flexible fuel) vehicle and engines
 - Not currently a legal blend
- Mid-level blends (20, 30, 40% ethanol by volume)
 - For use in FFVs only
 - Dispensed by “blender pumps” (<250 stations)
 - Specifications, etc. under development
- E85 (70-85% ethanol by volume)
 - For use in flex-fuel vehicles (FFVs) only
 - 7+ million FFVs; ~2,000 retail outlets
 - <2% of ethanol consumed as E85



Background of the DOE/UL team

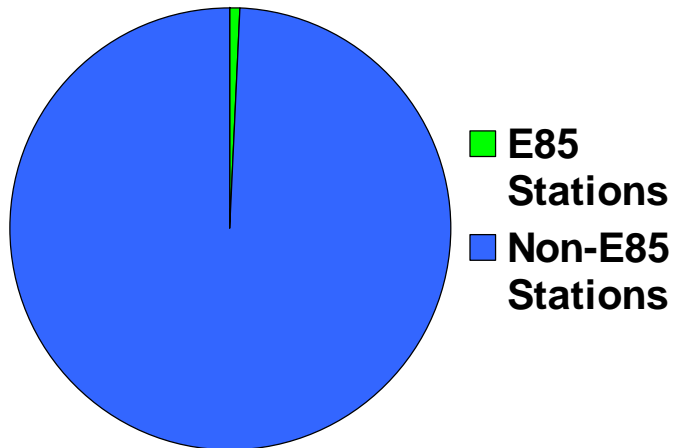
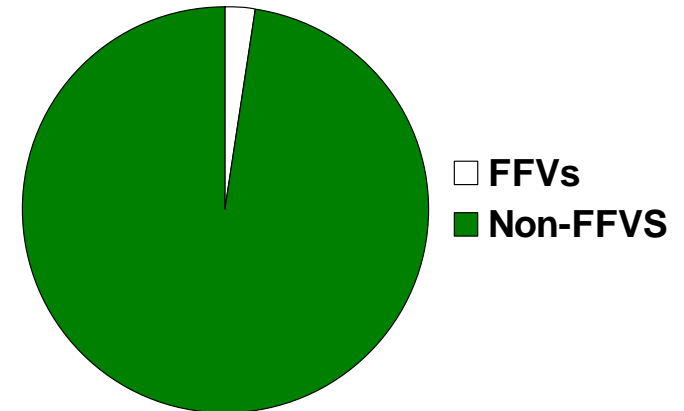
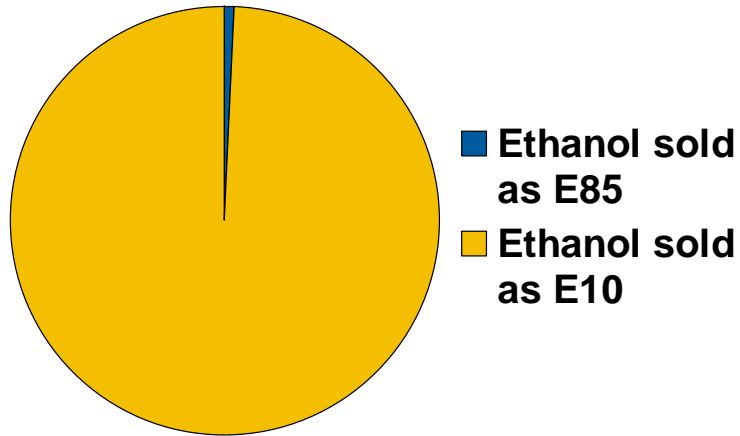
- **November 2006:** UL & DOE hold E85 Technical Forum, ultimately resulting in a protocol for UL listing of E85 dispenser equipment

Meanwhile:

- **June 2007:** DOE initiates investigation into effects of Intermediate ethanol blends (E15 – E20) on conventional vehicles, small engines in response to RFS1
- **November 2007:** NREL & Oak Ridge National Lab begin testing small engines on E15/E20, at EPA's request
- **January 2008:** NREL & ORNL begin testing modern vehicles on E15/E20
- Reports issued throughout 2008 & 2009, ongoing
- **Spring of 2009:** Infrastructure project initiated
 - Rationale: determine effect on existing new and legacy equipment – will E15/E20 be safe in today's hardware?
- **Fall 2009:** Testing begins with UL on compatibility of legacy dispensers



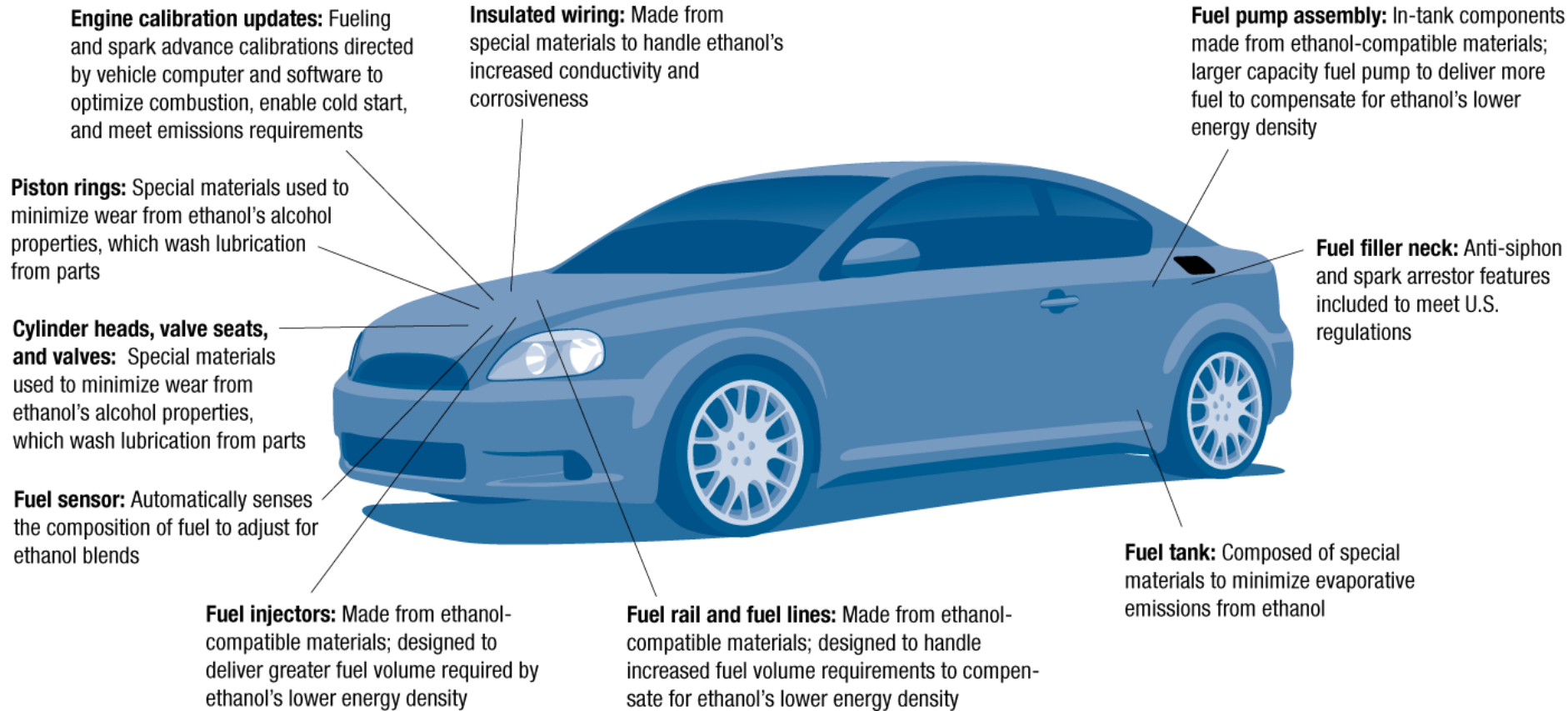
US E85 Infrastructure very limited



E85 Route to Solution:

- E85: 3 to 4 Orders of Magnitude more than today
- 100 million FFVs vs 7 million FFVs today
- 60,000 E85 stations vs ~2,000 today

How are FFVs different?



UL Dispenser Listing for E85

Oct. 2006: Underwriter's Laboratory and DOE team engage to resolve outstanding materials compatibility issues; NREL is DOE's lead

Nov. 2006: Meeting populated by industry experts and stakeholders

- Little quantitative data available (except by autos)
- Test fluids defined

Jan. 2007: Test plan developed by UL; ORNL invited to participate

Feb. 2007: Technical Panel met to review data and finalize test protocol; UL dispatches contingent to Brazil; UL releases ***“Survey of E85 Fuel Dispensing Operations in the US”***

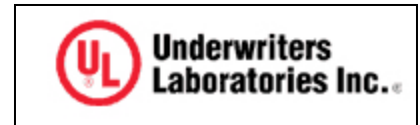
see: <http://www.ul.com/gasandoil/development.html>.

Mar. 2007 – October 2007: UL's research program completed

Oct. 2007: E 85 test procedure published by UL; dispensers and components begin to be tested (except hoses!)

Sept. 2009: Growth Energy announcement re: hose (“hanging hardware”) submission for testing

Fall 2009: UL has active program for hoses!



E85: Commercial E85 Fuel Survey

Scope: A comprehensive survey of commercially-available E85 fuel

Background:

- In previous surveys, most samples off-spec due to vapor pressure and/or low ethanol content

Status:

- 50/50 industry co-fund with NREL
- Draft report submitted to CRC for review Sept. 2009

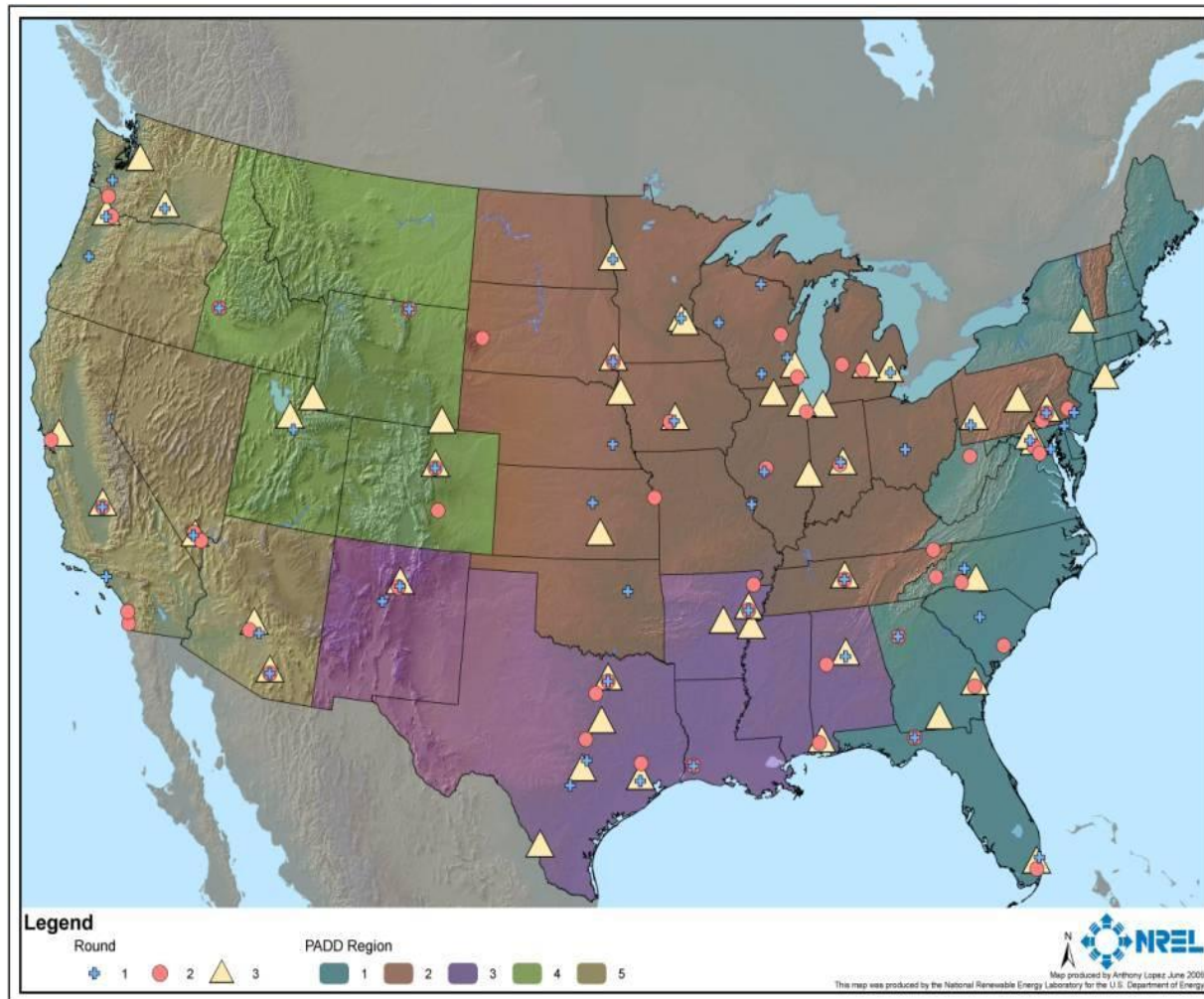
Benefits:

- Provides a picture of commercial E85 fuel quality
- Demonstrates that current trend to lower RVP gasolines, which is used as the HC blendstock, makes it difficult to meet specification - especially in Winter
- Indicates that when gasoline prices are higher than ethanol prices, blenders tend to “skimp” on hydrocarbon portion, resulting in off-spec ethanol content

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E85: Commercial E85 Fuel Survey

3 rounds of sampling from all 5 PADDs – broad coverage of market



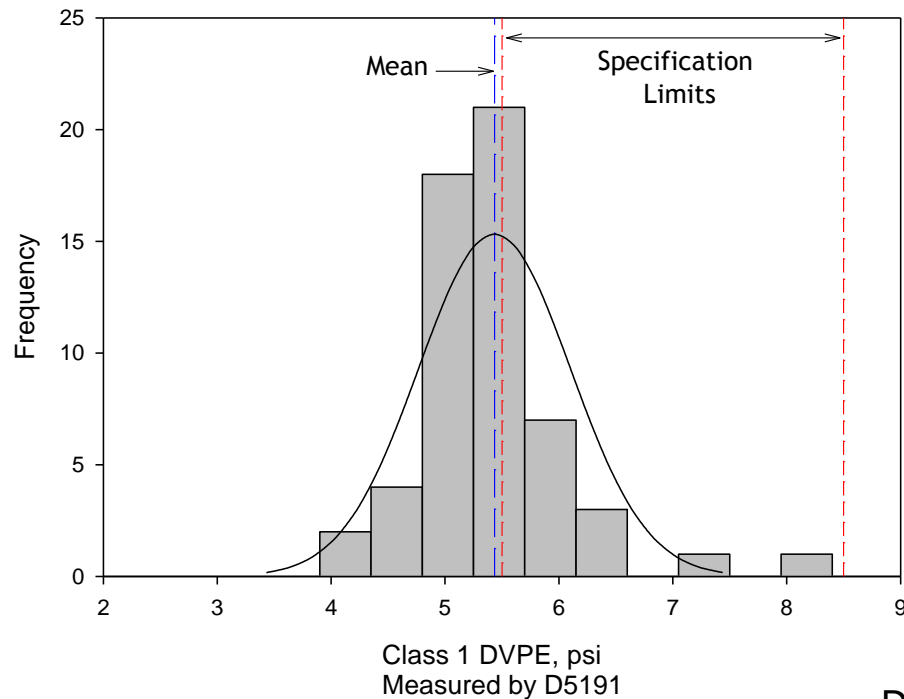
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E85: Commercial E85 Fuel Survey

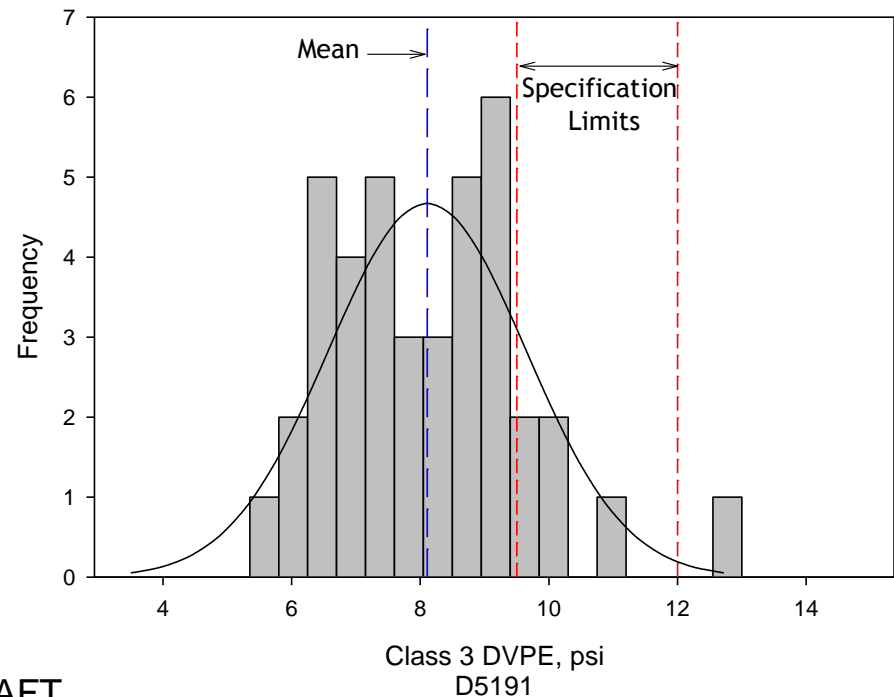
Results of testing: Vapor pressure

- 60% of Class 1 Summer time samples off spec on vapor pressure
- 85% of Class 3 Winter time samples off spec on vapor pressure

Summer 2008



Winter 2008-09



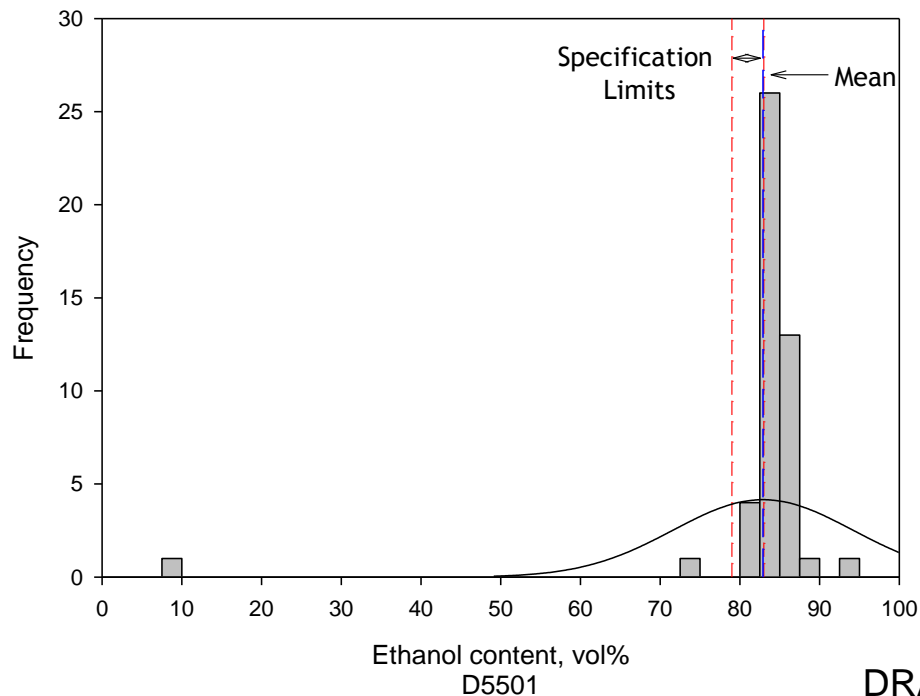
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E85: Commercial E85 Fuel Survey

Results of testing: Ethanol content

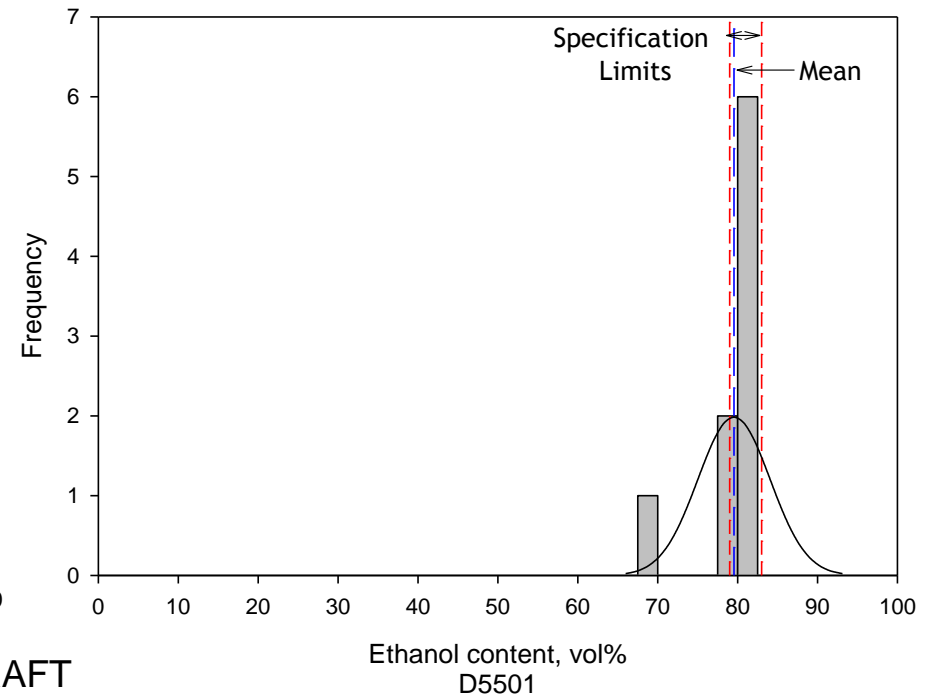
- 81% of 2008 Class 1 samples off-spec on ethanol (high gasoline \$)
- 10% of 2009 Class 1 samples off-spec on ethanol (gas. < ethanol \$)

Summer 2008



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Summer 2009



E85: Commercial E85 Fuel Survey

Results on other fuel properties tested:

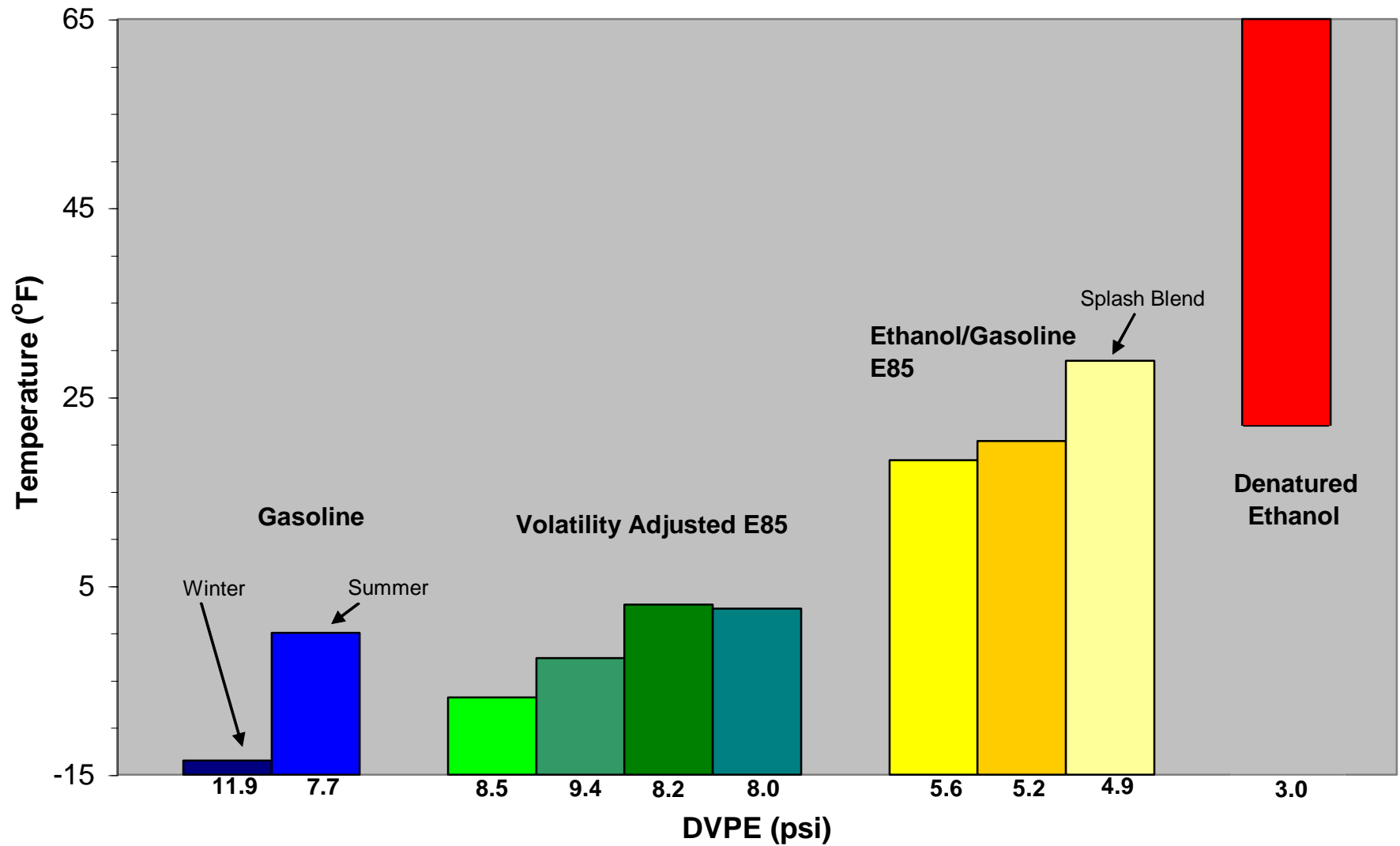
- 4% of samples off-spec on Acidity (0% off-spec on pHe)
- 2% of samples off-spec on Water Content
- 2% of samples off-spec on Chlorides
- 1 sample was off-spec for Peroxide Content
- 0% of samples off-spec on Oxidation Stability
- 0% of samples off-spec on Unwashed and Washed Gums
- 0% of samples off-spec on Sulfur content
- 0% of samples off-spec on Methanol content
- D86 distillation curve showed no samples with heavy HC content

E85 project team recommends continued, periodic E85 surveying

Flammability Limits on Fuel Tank Headspace Vapors

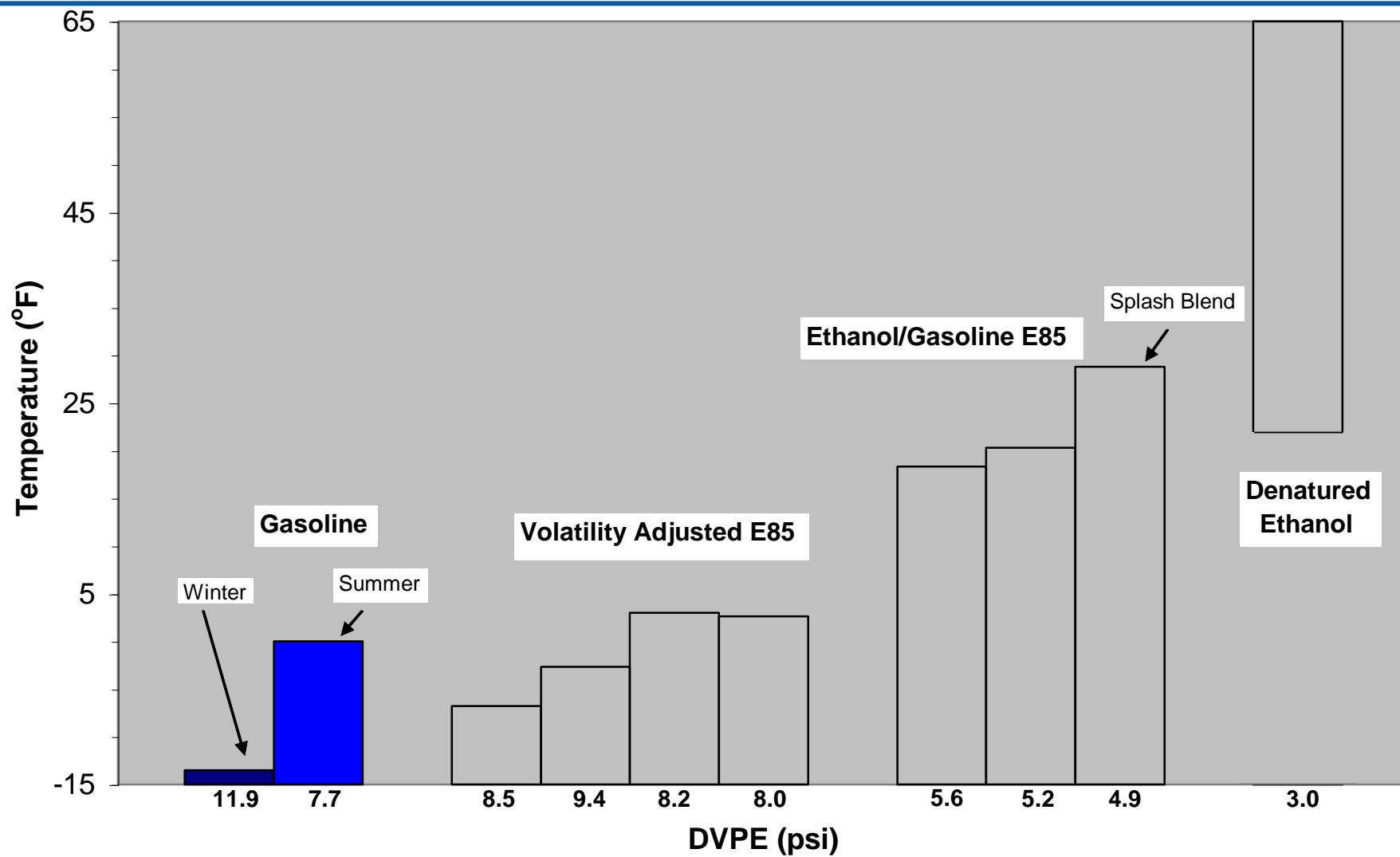
- DOE & NREL's support of the implementation of an **E85 infrastructure** includes evaluating the potential hazards associated with introducing a fuel with different physical and chemical properties to the general public.
- The vapors in fuel tanks containing gasoline are too rich to be flammable except at extremely low ambient temperatures.
- Fuels containing **high percentages of ethanol can have lower volatility than gasoline**, and may produce **flammable headspace** vapors at common ambient temperatures.
- Experiments were carried out to determine the effects of ambient temperature and fuel formulation on headspace vapor flammability.
- **E85 blends, gasoline, and denatured ethanol** (unfit for consumption) were compared using small instrumented pressure chambers equipped with a spark ignition source.

Flammability Limits of Fuel Tank Headspace Vapors

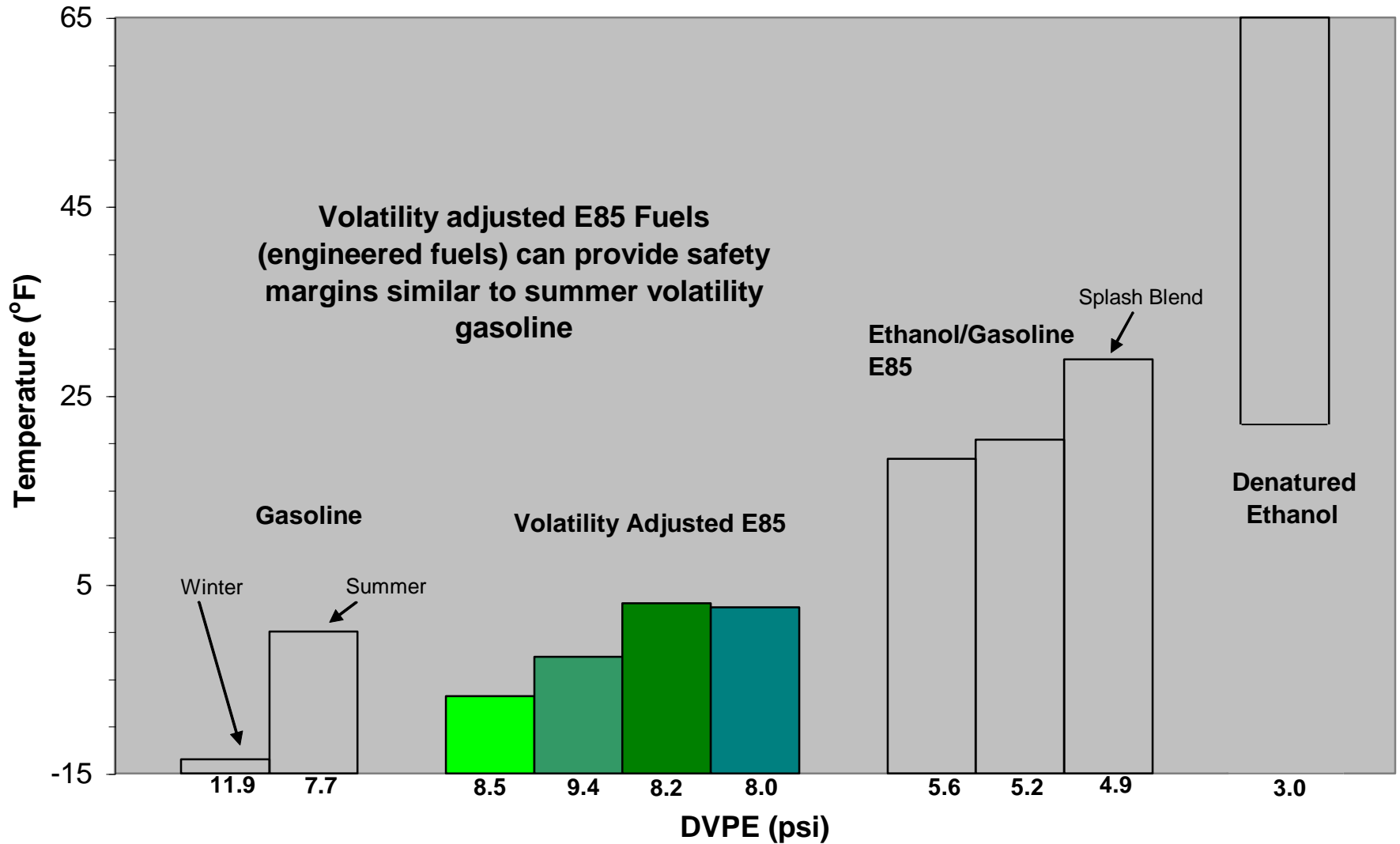


Flammability Limits of Fuel Tank Headspace Vapors

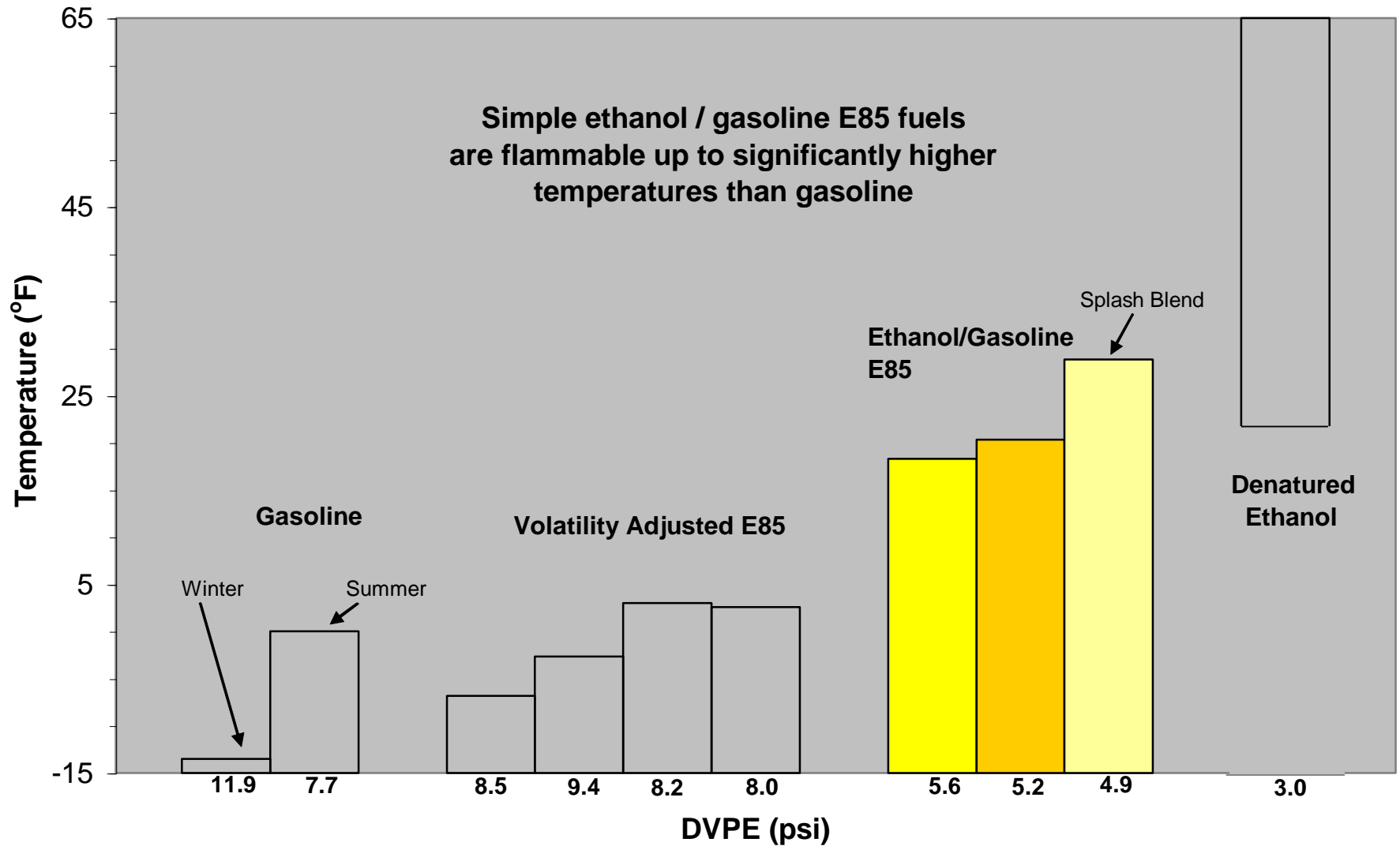
5% Fill Level



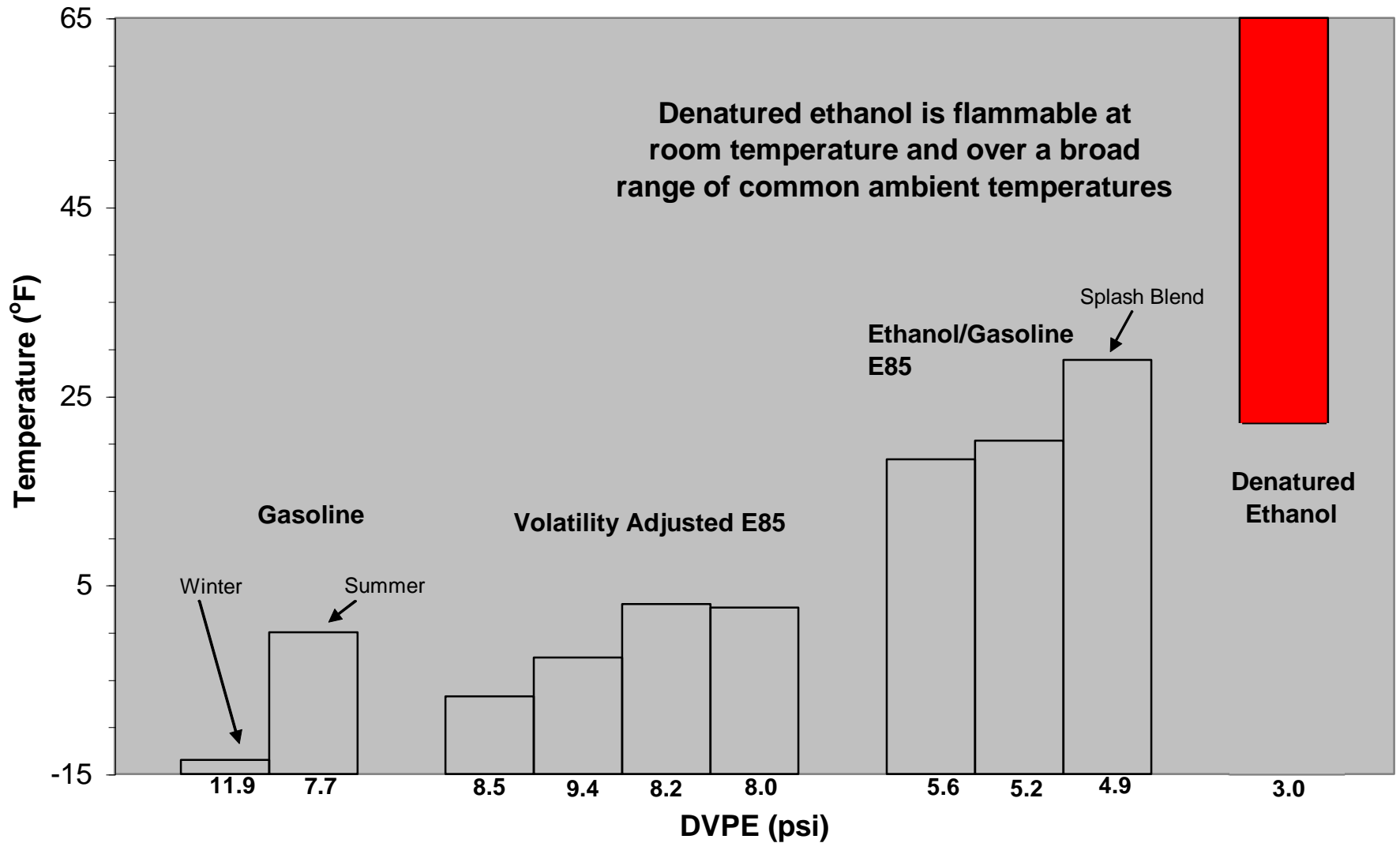
Flammability Limits of Fuel Tank Headspace Vapors



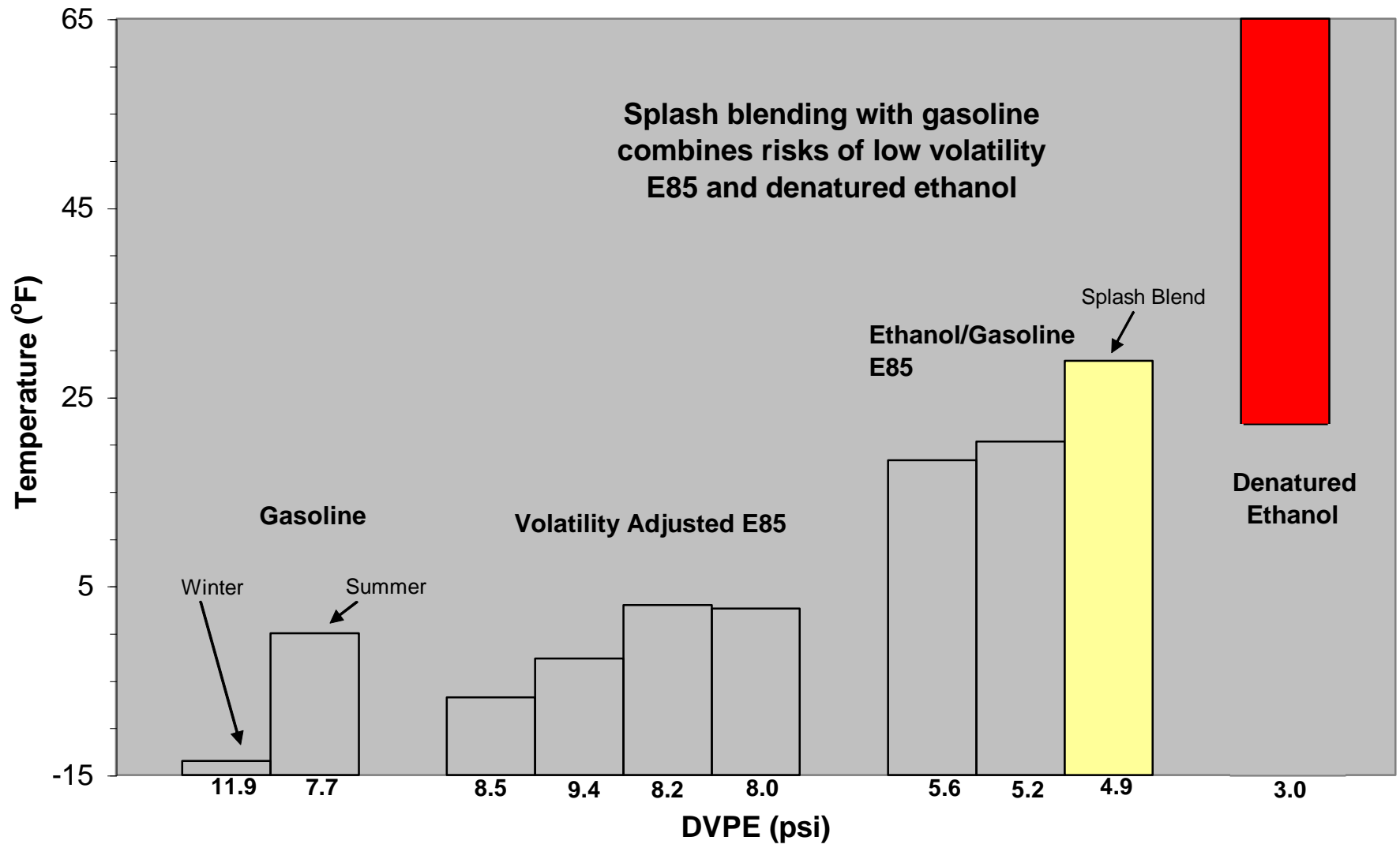
Flammability Limits of Fuel Tank Headspace Vapors



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Flammability Limits of Fuel Tank Headspace Vapors



Marathon suspends sales of E-85

- “As one of nation’s largest ethanol blenders, Marathon has a history of supporting renewable fuels and has led the industry in offering ethanol blended fuels. For many years, Marathon has been proud to offer a slate of renewable fuels including E85.”
- **Effective 9/23/09, sales were suspended**
- Cannot “...ensure the ASTM D 5798 minimum vapor pressure specification is met on a consistent basis throughout the year when blending with seasonal gasoline commonly available at terminals.
- “E85 fuels tend to have broader flammability ranges that occur at warmer temperatures.
- Marathon will continue to collaborate with the automotive companies, industry groups, and various state agencies to evaluate options to produce an E85 blend that consistently meets the ASTM D 5798 specifications.”

What is a blender pump?

- Blender pumps (or dial-a-blend) dispensers allow consumers to select mid-level ethanol content in fuels
 - Usually discrete increments (E20, E30, E50, E85)
- No fuel standards for blends between E10 and E85
- Pumps should be clearly labeled as for Flex Fuel Vehicles (FFVs)



Unknown Source



Courtesy: MN Department of Commerce

South Dakota Fueling Station



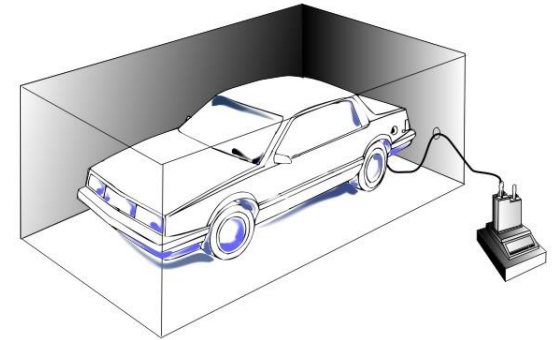
Survey Summary and Conclusions

- Quick “snapshot” was taken of samples from blender pumps for mid-level ethanol blends
- Pump labeling clearly shows “For Flex Fuel Vehicles”
- Data shows samples are meeting the gasoline specification but not the E85 specification
 - Need ASTM specification for mid-level ethanol?
- Some flush gallons had very high ethanol content, even after 3 gallons
 - Need to further investigate pump dead volumes
- Recommend following up with more complete survey on blender pumps from wider geographic region and multiple samples from each state

E15/E20 Conventional Vehicle Testing

- **Tailpipe Emissions** (with EPA)

- Testing 27 fuels on 12 vehicles at 75°F
 - Many types of E15 and E20 included among these fuels; one E85 as well
 - Three of these vehicles will be “high emitters”; others are 2008 models
- Report expected Spring 2010

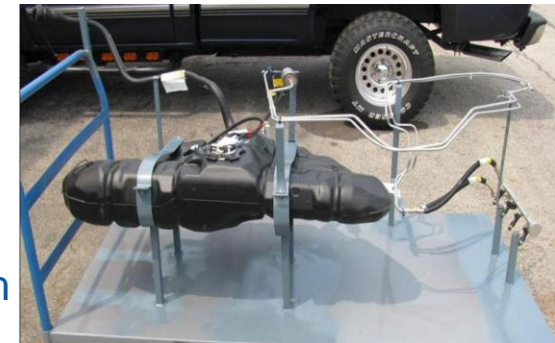


- **Evaporative Emissions** (with CRC and EPA)

- Testing E0, E10 and E20 on 16 vehicles, 2 vapor pressures
- Evaluating effects of ethanol blends on permeation and breakthrough of EtOH and HC through fuel system components
- Report expected Spring 2010

- **Fuel System Materials Compatibility** (with CRC)

- Testing E0, E10, aggressive E20
- Evaluating fuel system components, sub-system and system
- Results expected Winter 2009; report expected Q1 2010



- **Cold Start and Driveability** (with CRC)

- Winter 2008, tested 6 vehicles at cool temperatures
- Summer 2010, will test 6 vehicles (MY81-07) at high temperature, high altitude
- E0, E10, E15, E20



Additional Efforts

- **Marine**

- Test E0 and E15 on 4 engines to full useful life under wide open throttle conditions
- Emissions and durability
- To be conducted by marine industry



- **Chain saws**

- Safety testing due to concern re: unintended clutch engagement

- **ASTM fuel specification for “mid-level” ethanol blend**

- Mid-level ethanol blends group is writing spec for E30 to ~E60, particularly for use thru blender pumps



- **Rochester Institute of Technology Study**

- Conducting emissions testing on E0 and E20 on 10 vehicles
- Monitoring 400 vehicle fleet for abnormal fuel system failures
- NREL will assist with data collection and analysis

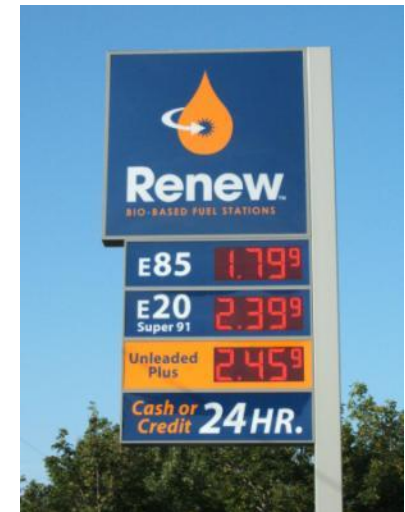
- **Kettering University**

- Conducted a study of the effect of E10 on collector car components for Hagerty Insurance
- Expand testing to include E15 and Tier 1 components



Ongoing & Planned Testing of Infrastructure Components (new efforts)

- **Dispensers** (including hydraulic trees and sub-assemblies)
 - Several used and most common new dispensers for performance based testing with UL
 - Harvesting legacy equipment – whole systems and components
- **Underground storage tanks**
 - Coupon testing of older tanks for materials compatibility (at ORNL)
- **Piping** and other distribution components
 - Used and new components to be tested
- Testing will start Fall 2009, completion over next two years



NREL Dispenser Testing

- Dispenser and Component Testing at UL's lab using Subject 87A-E25
- Test fuel is 'aggressive' E15, at 60°C to accelerate effects
- Testing will begin in the next few weeks (early Nov. 2009)
- Dispensers
 - 2 new dispensers (one with vac assist)
 - 4 used dispensers
 - From various areas of the U.S.
 - Two with vac assist and two without
 - Dispensers were selected based on market penetration



Information Resources

NREL – <http://www.nrel.gov>

DOE Office of Biomass Program - <http://www1.eere.energy.gov/biomass/>

EERE Info Center - www1.eere.energy.gov/informationcenter

Alternative Fuels Data Center - <http://www.eere.energy.gov/afdc/fuels/ethanol.html>

Bioenergy Feedstock Information Network - <http://bioenergy.ornl.gov/>

Biomass R&D Initiative – www.biomass.govtools.us

Grant Solicitations - www.grants.gov

Office of Science - <http://www.er.doe.gov/>

Effects of Intermediate Ethanol Blends on Legacy Vehicles and Small Non-Road Engines, Report 1 - Updated

– <http://www.nrel.gov/docs/fy09osti/43543.pdf>

Coordinating Research Council Publications -
<http://www.crcao.com/publications/performance/index.html>

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